Carrier Ethernet:
An Executive's Handbook

Contents

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Foreword

Ethernet is playing an ever-increasing role in every aspect of the access infrastructure. Not only is it becoming the de-facto universal service jack, but it is also poised to take on the role of the new universal transport technology. Moreover, the increased availability of carrier-grade features – such as rapid service restoration, hard QoS guarantees, strong service management, support for seamless TDM integration, and high scalability – makes Ethernet more suitable than ever as the infrastructure for several of telecom's hottest growth services: enterprise Ethernet, residential Triple Play, and mobility (where Ethernet is used for wireless backhaul traffic).

Carrier-grade features on new and existing network equipment is helping fuel high enterprise interest in Ethernet services today and ultimately will help accelerate the rise of Ethernet at the expense of legacy services. This is because carrier-grade features enable Ethernet to match and exceed the performance characteristics of legacy services, while at the same time providing a more flexible and familiar displacement alternative at a lower cost.

Beyond simply supporting more robust enterprise services, more and more service providers are embracing Carrier Ethernet as a critical service and network convergence technology useful for addressing a range of enterprise, residential, and mobile applications. The same type of Carrier Ethernet platforms that address tough enterprise requirements for mission-critical applications can also be used to build networks with the high scalability and low latency required to support residential Triple Play offerings. Carrier Ethernet's ability to provide guaranteed QoS and flexible Service Level Agreements (SLAs) makes it useful for addressing 3G/UMTS wireless backhaul requirements, too.

Stan Hubbard
Senior Analyst - Heavy Reading

The Advent of Ethernet

Ethernet technology has continually re-invented itself over the years to satisfy user requirements. It now supports a range of speeds from 10Mbps to 10Gbps and due to the open, flexible and simple nature of Ethernet, market prices are very competitive. Ethernet has won the Local Area Networks (LANs) battle and is today the ubiquitous technology which provides connectivity for over 97% of networking devices worldwide. Ethernet is the 'enterprise' LAN technology, why should it be used to deliver Carrier-class services?

Ethernet is used for various applications by different types of users including large enterprises, small and medium size businesses, central and local governments, application service providers, content repositories as well as residential users. All these users utilise telecommunications services to connect to the outside world and reach out to other services beyond the perimeter of their physical environment. In contrast, the Wide Area Network (WAN) market is dominated by the large, incumbent, national telecommunication service providers whose networks were designed predominantly to support voice telephony. Telecommunication service providers use their voice telephony network to provide customers with voice and data communications connectivity; they do not in general support end user applications or distribute content. This leads to the fact that all data communications services to and from customer premises use a range of technologies other than Ethernet, to transport, switch and route data. Data communication services use formats and technologies that are different to those used by their customers.

At any location where a customer needs to interface with the data communication service, the customer has to convert their data formats and interfaces to those acceptable and used by the service provider. Conversion adds cost and lowers performance for the customer where applications and not technology are the main focus and drivers of the business. Today, although Frame Relay and ATM services account for a major portion of service providers' revenue from the enterprise customer, Ethernet's low-cost, multiple access speeds, and familiarity to both enterprise and residential customers make this technology extremely attractive.

This handbook will explore how Carrier Ethernet technology is being developed and used to deploy Carrier services with superior efficiency while protecting existing service revenues and opening opportunities for new ones.

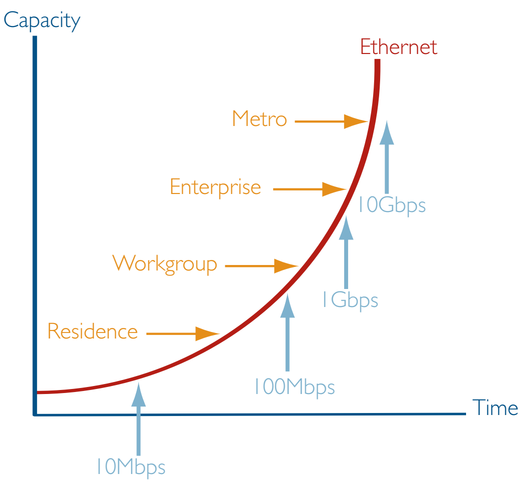
What is Ethernet Technology?

Packet-based Ethernet technology was developed in the 1980s for enterprise Local Area Networks (LANs). The technology is ubiquitous in the enterprise, in subscribers' homes and all application servers delivering IP-based services to all communication devices.

Due to the fact that Ethernet is embedded in all PCs, in servers, in wired and wireless LAN networking nodes, its components are manufactured in large volumes. This results in very attractive manufacturing costs when compared to other technologies used for the transport and switching of data.

Ethernet is an international, interoperable standard. Anyone who travels internationally with a laptop PC is confident that when the PC is plugged into an Ethernet LAN it will communicate - but cannot be sure they will be able to get AC power by using the power plug that comes with the same PC!

Ethernet provides the user with a flexible choice of networking topologies. It supports Point-to-Point (P2P) and Point-to-Multipoint (P2MP) connectivity. The resulting network topology can be implemented as a Star, Mesh or Rings.



- Data-centric
- Scalable Bandwidth
- Fast Provisioning
- Low Cost
- Wide Familiarity and Acceptance
- Standard-based
- Flexible Topology

Figure 1: Ethernet Technology in a Nutshell

What is Carrier Ethernet?

There has been a continuous debate for many years as to whether Ethernet is 'man enough' for the job of delivering carrier services to subscribers. A study carried out by Infonetics Research in April 2005 confirms that in the next 10 years 'Ethernet will inexorably take over the metro'. The survey included 37 incumbent and competitive providers from North America, Europe and Asia Pacific. This trend is strongly backed by unprecedented industry support from the major telecommunications equipment suppliers who have all embraced Ethernet as a base technology in their latest carrier-grade product offerings. Today, no one doubts that Ethernet is considered mature, in the eyes of both incumbent Telcos and alternative operators, as an accepted wide area technology suitable for the local access loop.

Service delivery is primarily based on the structure where a single Ethernet subscriber's port using Virtual LANs (VLANs) delivers multiple IP services to the subscriber. Figure 2 illustrates this convergence of multiple services being delivered by a single Ethernet access network.

Carrier Ethernet uses Ethernet as the base technology, and then adds specific features and functions to enable the resultant technology and equipment to be deployed in a carrier's network. These additional features and functions include:

Resilience

For equipment to operate in a carrier's network, it needs to be designed with resilience in mind to provide equal or better up-time than existing services.

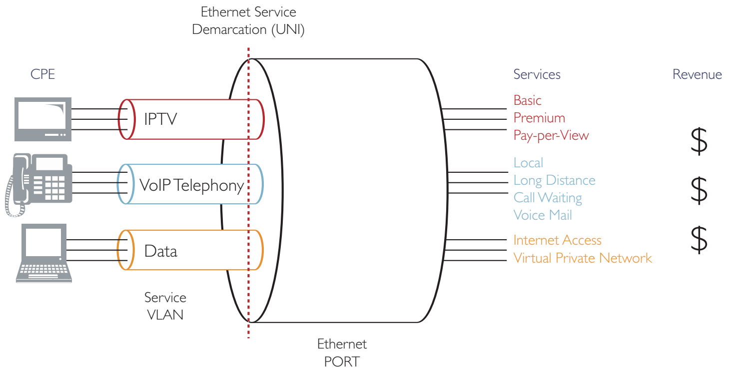


Figure 2: Carrier Ethernet Multiservice Interface

High Availability

In order to minimise service disruption in the event of a link or node failure, ring topologies are used to aggregate and transport traffic. Recovery from a link or node failure is required to be <50ms in order for the end user to discernibily not notice a failure in the network. Delivering Quality of Experience is paramount.

Scalability

Bandwidth scalability needs to be complemented by service scalability to support multi-customer environments. Hybrid Ethernet and IP/MPLS networks provide an architecture that overcomes restrictions and shortcomings of an all-Ethernet control plane.

Management

Ethernet service monitoring is enhanced by additional control-plane intelligence. Different standards bodies including IEEE, Metro Ethernet Forum (MEF) and ITU are very active in this area. In June 2004, the IEEE published the IEEE 802.3ah, Ethernet in the First Mile (EFM) standard, specifying link OAM (Operation, Administration and Management) using an Ethernet frame-based approach. The standard includes mechanisms useful for monitoring link operation such as remote fault indication and remote loop back control. The OAM architecture provides carriers the ability to monitor the health of the network and quickly determine the location of failing links or fault conditions.

'Any' Transmission Media

Carrier Ethernet requires that Ethernet frames be transported over 'any' transmission media (copper, fibre, free space optics or wireless) available in the local access loop.

Service Interworking

Ethernet interoperability and ubiquity needs to be enhanced to interwork with legacy deployments such as existing Frame Relay and ATM networks. Pseudo-wire technology enables full service interworking in a Hybrid Ethernet and IP/MPLS (Multi-Protocol Label Switching) network architecture.

Carrier Ethernet Service Types

The Metro Ethernet Forum (MEF) has defined two Ethernet service types:

- Ethernet Line Service (E-Line)
  This is a Point-to-Point (P2P) Ethernet service and is used for
  - Private Line Services
  - Ethernet Internet Access
  - Point-to-Point VPNs
- Ethernet LAN Service (E-LAN)
  This is a Multipoint-to-Multipoint (MP2MP) Ethernet service and is used for
  - Multipoint Virtual Private Networks (VPNs)
  - Transparent LAN Service

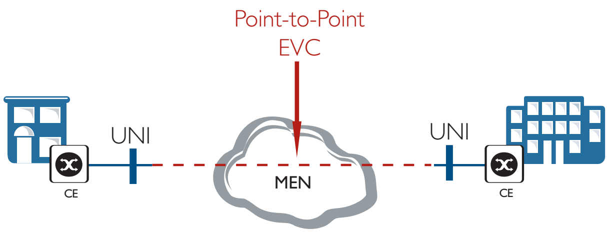


Figure 3: E-Line Service using Point-to-Point EVC (Source: MEF)

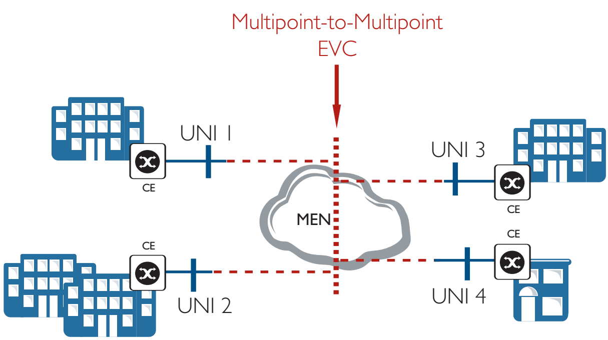


Figure 4: E-LAN Service using Multipoint EVC (Source: MEF)

User-to-Network (UNI) represents a standard Ethernet interface and is the point of demarcation between the customer equipment and the service provider Carrier Ethernet network.

Ethernet Virtual Connection (EVC) is the logical tunnel that connects two or more sites and is similar to Permanent Virtual Circuits (PVCs) in Frame Relay or ATM.

Maintaining Revenue-Generating Services

Circuit Emulation Service over Packet (CESoP) technology in the access network combined with Pseudo-Wire (PWE3) technique, current revenue-generating services such as leased lines, ATM and Frame Relay services are maintained within a next-generation hybrid Carrier Ethernet and IP/MPLS network architecture.

Pseudo-wire is a mechanism that emulates the essential attributes of an existing Point-to-Point service (e.g. E1/T1 leased lines) over a packet-centric network (IP/MPLS). Pseudo-wires provide functionality that emulates the behaviour and characteristics of existing Telco services (e.g. ATM, Frame Relay) through an IP packet network. From the customer perspective, the Pseudo-wire is perceived as an unshared link or circuit of the chosen legacy service.

The Internet Engineering Task Force (IETF) has defined a way to carry all Layer 2 traffic over an MPLS/IP network. This is what's known as 'draft-martini' encapsulation in reference to the author of the original draft, Luca Martini.

Using Pseudo-wire technology the Telco has the freedom to incrementally migrate existing services over to Carrier Ethernet in the local loop as and when the opportunity arises to update infrastructure in specific geographic areas.

In fact, Pseudo-wire technology squeezes additional revenue from the existing Telco's copper and fibre networks and enables existing services to be migrated to an all packet-based core infrastructure. The following table summarises how these emulation technologies maintain existing services revenues.

Table 1: Emulation of Traditional Services over Packet Networks

Technology	Maintaining Revenue
E1/T1 Circuit Emulation Service-over-Packet (CESoP)	**Maintain E1/T1 leased lines revenue**
VoIP POTS-over-Ethernet Media Gateway	**Maintain PSTN revenue with lower OPEX**
ATM and Frame Relay-over-MPLS/IP (draft-martini)	**Maintain E1, E3, E4 and STM-1 revenue**

Why Carrier Ethernet Now?

Dominance and Ubiquity

From a carrier's perspective, Ethernet and IP dominate the customer's premise and the Application Service Provider's (ASP) server farms. Most data traffic carried in a Telco's network begins and ends as Ethernet frames.

Today, Customer Premise Equipment (CPE) is turning into a Customer Premise Network (CPN) where Entertainment, Telecommunication and Computing are converging. Ethernet support is standard on most customer devices and appliances and will continue to drive sharing, collaboration and smart home applications and services. Telecommuting is one of the largest drivers of home networking today. According to a survey carried out by Recom Research in August 2005, in the UK alone, there are over three million home workers today using the Internet to access work and enterprise services.

Broadband Aggregation

The increase in traffic due to the rapid adoption of 'broadband', primarily using xDSL services, is driving the need for higher capacity backhaul links from the Central Offices and Remote Nodes. Today worldwide DSL subscriptions have exceeded 100 million subscribers and are projected to continue at double digit growth rate over the next five years. Furthermore, improved access technologies are squeezing more bandwidth out of the copper plant and in May 2005, the VDSL2 standard was ratified by the ITU giving operators the opportunity to deliver symmetric speeds of up to 100Mbps (<300m). The VDSL2 standard supports fallback to the recently deployed ADSL2+ technology with 24Mbps downstream and up to 3Mbps upstream.

Fibre-To-The-Home/Business is also starting to gain momentum and will require even higher capacity in the backhaul.

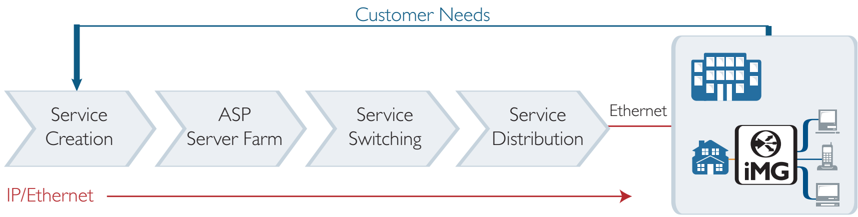


Figure 5: Carrier Service Delivery Value Chain

ATM aggregation is complex, expensive and lacks support for true IP Triple Play services. Carrier Ethernet provides a scalable and affordable architecture that supports the growing traffic aggregation requirements for current and future next-generation access technologies, these include: ADSL2+, VDSL2 and FTTH (Active, Ethernet and PON).

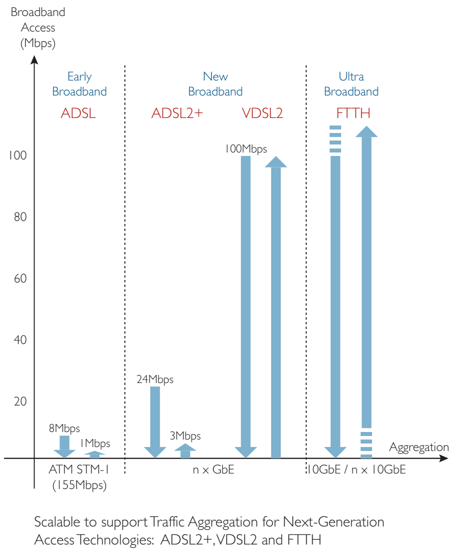


Figure 6: Broadband Access Technologies Aggregation Requirements

Protected Transport Rings for Maximum Quality of Experience

When delivering carrier-grade services involving multimedia applications, operators have the challenge of meeting stringent Service Level Agreements (SLAs) with their customers. Providing ultra fast network recovery is a mandatory requirement for voice and video services, to ensure continued customer satisfaction, loyalty and retention.

Carrier Ethernet supports protected transport rings technology, known as Ethernet Authentication Protected Switching (RFC 3619). EAPS provides a survivable resilient topology with sub-50-millisecond (SDH-like) failover capabilities. Furthermore, Carrier Ethernet protected transport supports multiple simultaneous overlapping rings (for spatial reuse), multiple subtended rings and multiple independent rings for flexible topology deployments. Because EAPS is a protocol which runs on top of standard Ethernet, there are no specific interface limitations; meaning it could run on 10Mbps, 100Mbps, 1GbE or 10GbE interfaces.

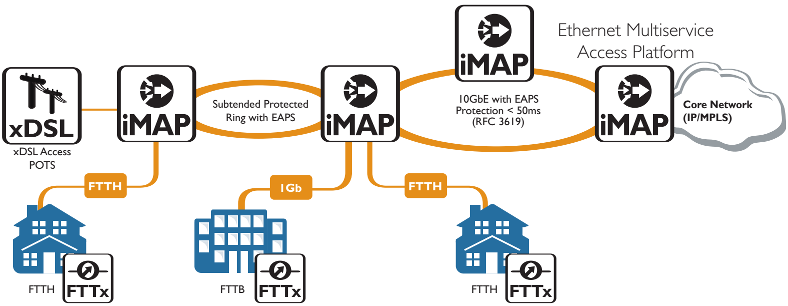


Figure 7: Ethernet Protected Transport Rings: Quality of Experience

Competition from Technology Displacement

Today services are delivered to subscribers in the Telco's local loop over copper twisted pairs. Service providers today use multiple parallel access networks to deliver their portfolio of services to customers. The access network is based on Time Division Multiplexing (TDM) technology and each service requires a separate and different Network Termination Equipment (NTE); each NTE is service specific and presents a different physical and logical interface to the customer.

The major Telco services are:

- Class 5 PSTN switch for POTS/ISDN service
- E1/T1 leased lines
- SDH/Sonet TDM transport for higher bandwidth leased lines
- 'Broadband' DSL delivered from Central Office based ATM DSLAMs
- Virtual Private Network (VPN) services delivered on ATM and Frame Relay
- Metro Ethernet service delivered over SDH/SONET technology using GFP

Incumbent Telcos are facing challenges on many fronts. Throughout their history, their major source of revenue has been the Public Switched Telephone Network (PSTN) and switched voice services carried on that network. In recent years, some competitive pressures have emerged, stimulated by the government via privatisation and deregulation.

For many Telcos, and for their regulators, local exchange competition has been viewed as 'like-for-like' services. That is, the competition to the wire line PSTN is believed to come from new companies offering similar services over similar networks. Often, as per regulatory requirements, the incumbent is required to 'unbundle' the 'natural' monopoly networks, and the competitive services are offered over the incumbent Telcos' local exchange network. Recent operational and financial data of incumbent Telcos points to a very different dynamics - competition is due to new technology which is causing revenue displacement.

The new technology is state-of-the-art IP-based applications that create the alternative services, such as Voice-over-IP (VoIP), which is replacing the traditional way Telcos create and deliver POTS telephony services. Table 2 provides examples of the changing landscape in the telecommunication industry.

Within this new framework of competition, service revenue becomes decoupled from the Telco's access network limiting the revenue growth of the Telco unless the Telco seizes the opportunity and upgrades its access network to one supporting in-built IP applications that can deliver multiple services to the subscriber.

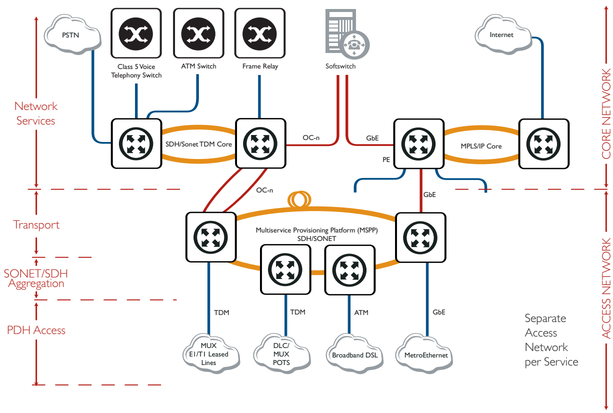


Figure 8: Typical Network for Incumbent PTT

Table 2: The Changing Landscape in the Telecommunications Industry	
Today's Local Loop	**Tomorrow's**
Incumbent/PTT Wire line POTS	**Wireless cell phone competition**
Incumbent/PTT 'near' monopoly	**Deregulation (CLEC, OLO, MSO)**
Dial-up to the Internet	**'Always on' broadband**
TDM technology	**Ethernet/IP packet technology**
POTS service – single service per network	**'Multiservice' (voice, video and data)**
IP Routing	**IP/MPLS**
ATM cells	**IP and Ethernet packets**
Copper	**Copper, Fibre and Wireless**
Sonet/SDH transport	**Ethernet-over- 'any media'**
Truck Roll service	**Self service via Web Portal**
Data-over-voice per circuit	**Voice-over-IP (VoIP), Video-over-IP (IPTV)**
E1/T1 leased line	**E1/T1 Circuit Emulation-over-IP**

The Journey to IP and MPLS

The issue at hand for carriers and network service providers is how to balance the investment required in deploying an IP infrastructure to enable future revenue growth from IP services, and continuing to invest in legacy networks to ensure continuance of existing, high-margin, revenue streams. Investment can become split between various networks diluting the growth of and strategic investment in IP networks. Such split investment in disparate networks effectively prevents a service provider from making a 'technology leap.' Alternatively, competitive providers with IP-only networks have been required to forgo revenues from the legacy services. Cost of Ownership (maintenance, operating expense, capital expenditure, etc.) for managing separate networks is tremendous. Each of the individual networks is under-utilised, creating a higher cost of transmission and bandwidth inefficiencies. The challenge is to protect the continued growth of carriers' revenue producing legacy services while avoiding additional investments in 'old' technology. Service providers need a cost-effective way to support multiple services over a unified IP network to retain ongoing revenue from legacy services and to generate additional revenue from new IP services.

Historically, every additional service required building a separate network which resulted in the operators having many overlays to run each support system. Deploying service-specific networks has become cumbersome and

expensive to operate reliably. The creation of a single converged core network capable of delivering multiple services is highly attractive for reasons of flexibility, economies of scale and operating efficiencies. Multi-Protocol Label Switching (MPLS) has become the ubiquitous de-facto protocol in the core network to encapsulate and route traffic between the access/distribution network and applications.

IP/MPLS uses packet-based technologies and its connection-oriented features to deliver traffic engineering and enhanced resilience using Fast Re-route. These benefits, coupled with features such as DiffServ coding will enhance the QoS of the IP network, making IP/MPLS a natural choice for the converged core network and a popular delivery mechanism for new services at the network edge.

Having separate networks for each service has become something of the past and many carriers and service providers today (e.g. BT 21st Century Network, Interoute, TeliaSonera, Lyse) rely on IP and MPLS to converge services onto a single core backbone network, with the resultant capital and operational savings.

As a natural follow-on to a converged core based on IP and MPLS, the metro and access networks are evolving to be based on Carrier Ethernet technology in order to implement an end-to-end multiservice architecture. Operating one network for multiple services is more cost efficient than one network per service - revenue growth comes from delivering 'content' to subscribers using IP applications.

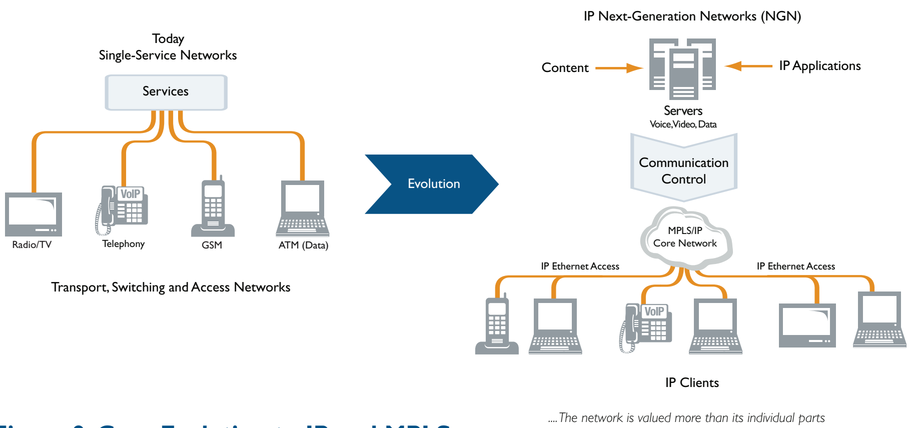


Figure 9: Core Evolution to IP and MPLS

IP Triple Play and Carrier Ethernet: Twins for Success

IP Triple Play Services

Carriers today know that transport services alone - however 'fat' the pipe - will not drive revenue growth to meet both investors' expectations and growing customer demands. New services are required to offset declining revenues, face up to increasing competition and to enable growth whilst delivering the rate of profitability demanded by the investment community. Operators need a simple and flexible network architecture that will deliver voice, video and data services that can realise significant multipliers of current revenues per subscriber, known as Average Revenue Per User (ARPU). A recent study conducted by The Yankee Group research organisation demonstrated that an ARPU of €90 can be reached when delivering IP Triple Play services.

IP 'Triple Play' refers to the integration of Internet access (data), telephone (voice) and TV (video) on a single IP network and bundled under a single brand.

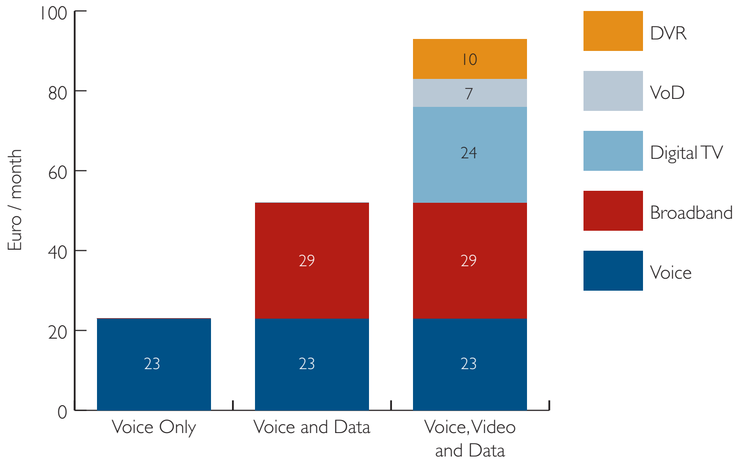


Figure 10: The IP Triple Play ARPU Opportunity (Source: Yankee Group, 2005)

IP Triple Play Broadband Carrier Ethernet

Deploying new IP applications, like IP Triple Play, requires additional bandwidth in the local loop. Additional bandwidth can be made available by implementing Fibre-To-The-Node/Curb (FTTN/FTTC). Implementing fibre to a remotely located node and shortening the existing copper pairs will deliver increased bandwidth over the existing copper loop. A more future-proof approach would be to deploy a new fibre-optic infrastructure all the way from the Central Office (CO) to every subscriber in a full Fibre-To-The-Home (FTTH) architecture. Although FTTH represents significant investment and a long-term commitment on the part of carriers and operators, it is likely to allow the emergence of completely new services and applications that will drive revenues and growth for operators in the future. These new services will range from video-telephony to tele-medicine as well as new collaboration tools for life-long education and new ways of working that operators will be able to sell and charge for.

The bandwidth required to support a mix of Standard and High Definition TVs as well as High Speed Internet Access (HSA) and VoIP telephony to a typical subscriber is ~25Mbps. Figure 11 shows the different services required by IP Triple Play subscribers and their projected bandwidth needs based on an internal market analysis.

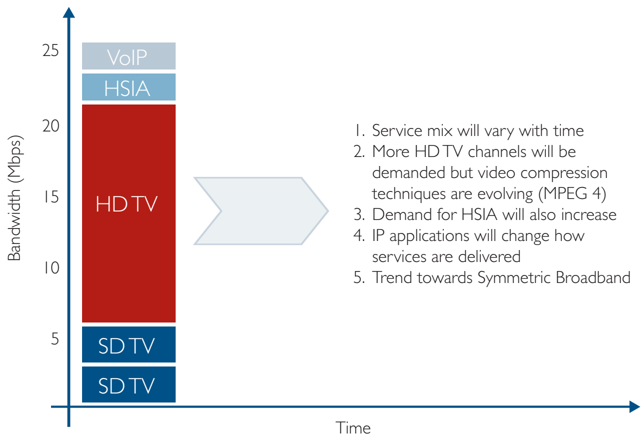
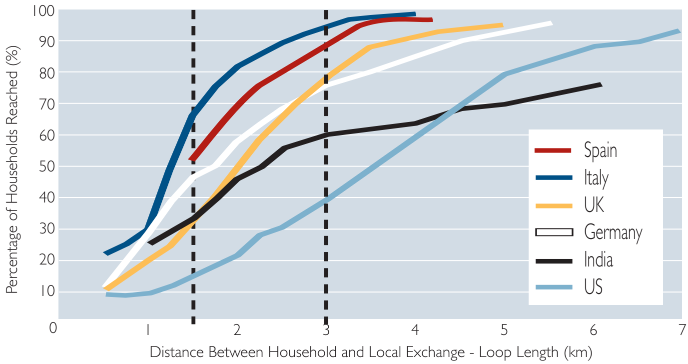


Figure 11: Projected Bandwidth Required by Household (Source: Allied Telesis 2005)



Source: Organisation for Economic Cooperation & Development (OECD)

Figure 12: Regional Variations in Loop Lengths and Reachability

Improvement in xDSL transmission and MPEG image compression technology requires that the subscriber be located at a distance of approximately 1 to 1.5km from a communications node (Central Office or Remote Node) that supports copper pairs. Depending on the country and region, the distances at which subscribers are located from the Central Office (CO) varies significantly. The US has a greater number of subscribers serviced by 'long' copper loops compared to the EU, primarily due to the fact that the density of European subscribers per square metre is higher, and thus the loop lengths are shorter. Therefore the percentage of customers serviced directly out of the Central Office (CO) is higher in Europe compared to the US. Figure 12 shows strong variations between countries in the percentages of households reached versus their distance from local exchange (CO).

To achieve speeds of 24Mbps per household and beyond over existing copper lines using ADSL2+ and VDSL2 technologies, fibre needs to be installed deeper in the access network and as close as possible to the subscriber. The recently published VDSL2 standard allows speeds of up to symmetric 100Mbps (symmetric) over loop lengths of up to 300m. Figure 13 suggests a reference model which combines a generic version of Figure 12 with the different levels of bandwidths available using xDSL technologies. The reference model outlines the addressable household market for an IP Triple Play service based on 24Mbps per subscriber. To reach out with IP Triple Play services to the remainder of the households, fibre needs to be deployed deeper in the access and nearer to the subscriber (FTTN/C).

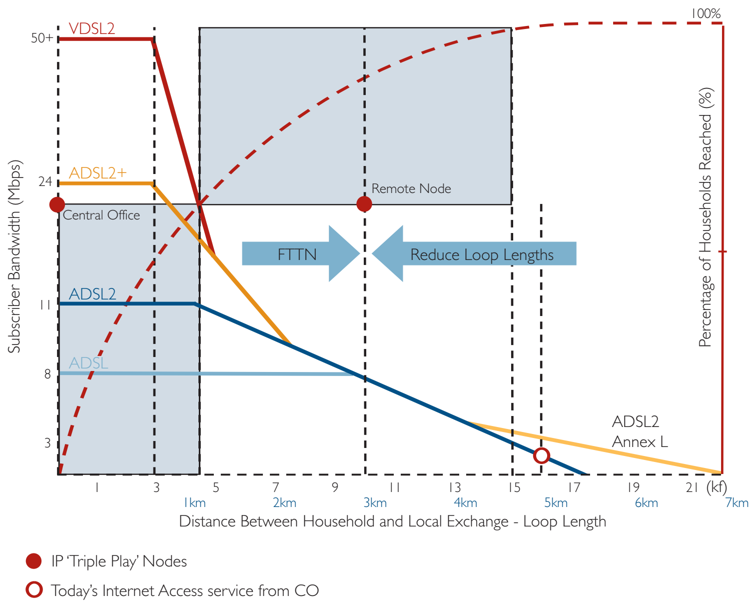


Figure 13: IP Triple Play Addressable Households Reference Model

IP Next-Generation Carrier Ethernet Networks

PTTs, ILECs and competitive service providers are migrating to IP/MPLS packet networks which consolidate multiple services in the core. Changes in the core network cannot take place in isolation from other parts of the network and the largest component of any carrier service deployment, the access network, is no exception. Carriers will recognise that if the access network was also consolidated into one unified delivery platform for access, aggregation and transport, it would minimise their CAPEX and give improved operational efficiencies. The multiservice capability of the access network would allow the service provider to generate new revenues from innovative service offerings. Figures 14 and 15 respectively illustrate a typical next-generation network architecture design for a PTT/ILEC carrier and a competitive operator .

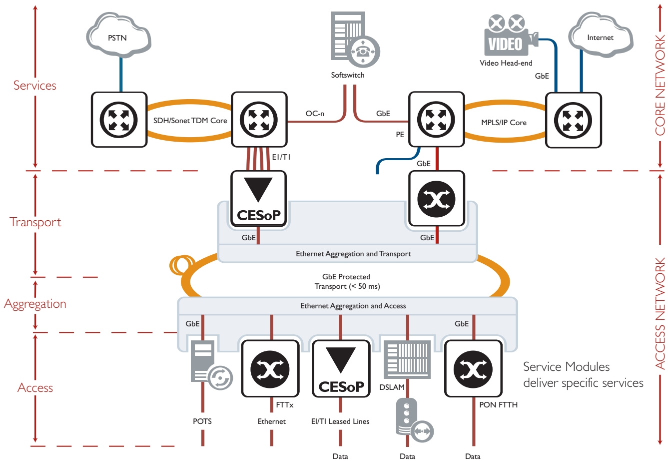


Figure 14: Typical Next-Generation Network for an Incumbent Telco

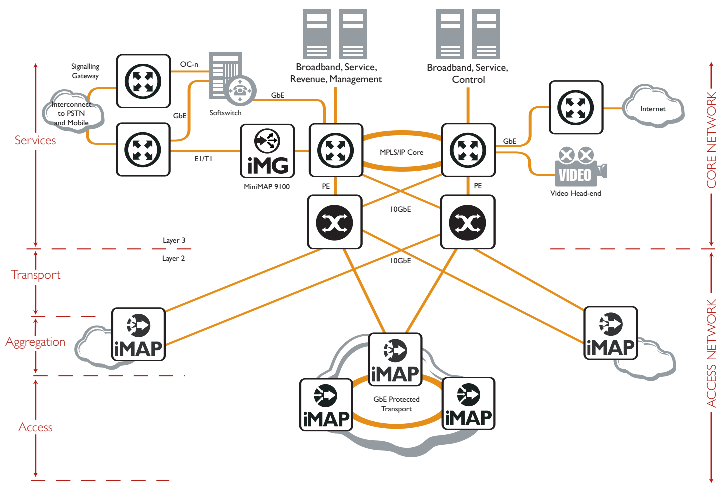


Figure 15: Typical Next-Generation Network for a Competitive Operator

The IP/MPLS domain creates a level of hierarchy that allows delivery of Ethernet and other Layer 2 services such as Frame Relay, ATM and E1/T1 lines to be delivered by the access segment of the network and provides the scalability required to carry these services end-to-end across the entire network.

Fibre-To-The-Building: Worldwide Outlook

Fibre has several clear advantages over today's dominant broadband access technologies (e.g. DSL and Cable). Firstly, it offers dedicated symmetrical bandwidth capability supporting an unlimited number of users connected to a local access node. Importantly, fibre supports much higher upload and download speeds than other access technologies, making it far better suited to bandwidth-hungry applications, such as video streaming and e-learning.

Implementing Fibre-To-The-Building (FTTB) is common practice in countries like Japan, Korea, China and India. In the new EC member states (Romania, Hungary and Poland) and developing countries with large populations (China and India) the existing communications infrastructure does not have a large installed base of copper twisted pairs relative to the size of the country and population. Therefore, if a new communications infrastructure is to be built, then the sensible strategy is to install fibre, not just to a node (FTTN) near to a building, but actually to the building itself (FTTB/FTTH). The density of potential customers in developing countries is high, however, even though earning levels are rapidly rising, the available disposable income may not be at a level that would cause a large number of customers to sign up for a 'broadband' service. Therefore, small distributed Carrier Ethernet nodes are more suitable for deployment in these regions.

Fibre installed to a building (FTTB) infrastructure is ideally suited for the use of Internet and LAN technology to distribute IP-based application services within the building. The in-building portion of the network would be implemented using well-proven LAN technology using fixed function distributed nodes – 'pizza boxes' to convert the fibre to multiple copper connections. A 'pizza box' would only be installed in a building when there are enough paying subscribers for services to justify the investment. Like the Internet and LANs in the enterprise, intelligence is distributed towards the edge of the network. In a typical 'incumbent' Telco's network where the Telco has a natural monopoly the tendency is to place the 'intelligence' at an aggregation point, like a large chassis located in a Central Office (CO).

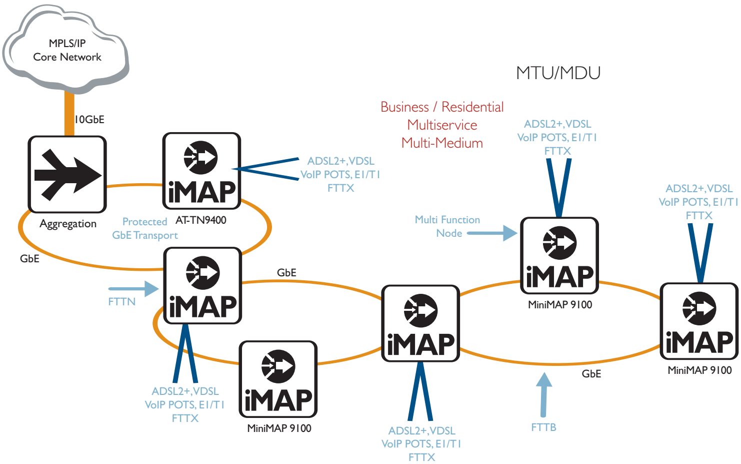


Figure 16: Fibre-To-The-Building: Protected Transport Multiservice Access

This centralised approach favours a large chassis-based node supporting Fibre-To-The-Building (FTTB) with Point-to-Point Ethernet or an Ethernet Passive Optical Network (EPON). Centralised solutions require the service provider to build the CO-based network with the hope that they will achieve the required number of customers to support the investment. The distributed 'pizza box' approach requires the physical fibre infrastructure to reach the building, but 'pizza boxes' are only installed in the buildings when the service provider has successfully sold the service.

The centralised CO-based network model is suitable for incumbent carriers with a 'near' monopoly of the local access loop. The distributed Fibre-To-The-Building (FTTB) approach is more appropriate for 'competitive' service providers in the developed countries and all service providers in developing countries.

Service Revenues from IP Network Applications

Innovation

The use of digital technology and a common IP infrastructure is causing the 'convergence' of three large industries – Computing, Telecommunications and Entertainment. It is the common IP infrastructure that enables multiple services to be delivered to customers over an Ethernet interface by 'new' IP applications.

This new communication infrastructure generates many opportunities for innovative software to create 'new' IP-based services. Revenue is derived by charging for the use of the IP applications and the content delivered, not necessarily by the basic connectivity service. Table 3 on the next page is a snap-shot of services delivered to subscribers by non-incumbent operators.

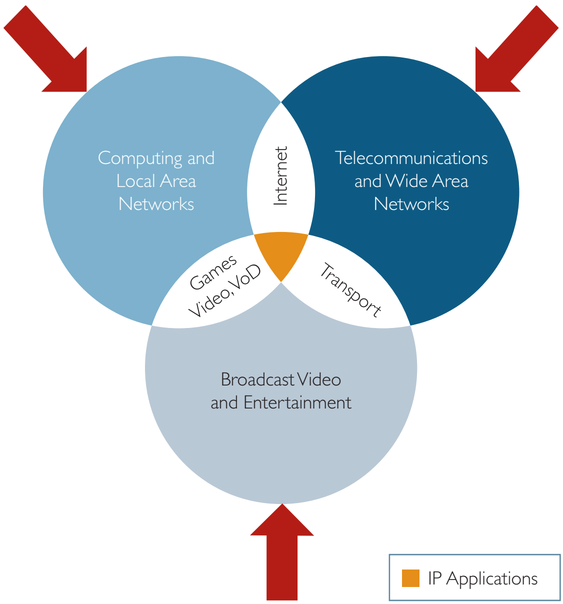


Figure 17: Dynamics of Convergence

Table 3: IP Services Delivered by Non-incumbent Operators		
IP Application	**Subscriber Device**	**Service Provider**
VoIP	Telephone	Vonage, AT&T, Skype
E-mail	PC	ISP
Short Message Service (SMS)	Cell Phone	GSM Operator (Vodafone)
Music jukebox and music downloads	Apple iPod	Apple iTunes
Presence – Instant Messaging	PC, PDA, Cell Phone	Yahoo, Microsoft MSN
Photo albums and image sharing	PC	Google
Voice Mail	Telephone, Cell Phone, PC	Vonage, Skype, Telco
Smart Home (security, intelligent appliances)	Home Gateway	Utilities, Municipalities
E1/T1-over-IP	Business Gateway	Tiscali France, Shanghai Mobile
Multicast Video-over-IP	Set-Top Box	Matanuska Telephone Association, Lyse Energi, Com-x, FastWeb, Ila Energi, Free
Video-on-Demand (VoD)	Personal Video Recorder (PVR)	Time Warner, Matanuska Telephone Association, Lyse Energi, FastWeb, Ella Energi, Free
Unified Messaging	Telephone	K7.net, Segway
Fax-over-IP	PC	eFax, MyFax, Venali
Pod-casting	MP3 Player (iPod)	Apple iTunes
Music downloads	MP3 Player (iPod)	Apple iTunes
Games-on-Demand	Gaming Console	Microsoft Xbox, Sony Playstation
Web Portal	PC, Web Stations	Yahoo, Google
Storage-on-Demand	PC	ICC, STAR, 3PARdata Inc
Wireless	WLAN Device (PC, PDA)	Hotels, Airports, ISPs, GSM Operators

Economics

In a Carrier Ethernet network the customer can access 'new' applications from the same single Ethernet interface. Therefore, once a Carrier Ethernet access network is deployed, the customer acquisition cost is marginal to zero for a 'new' service delivered by the next IP application. A Carrier Ethernet-based IP network supports all IP applications – (voice, video and data). It is not necessary to deploy a 'new' network in order to deliver a 'new' service. Carriers charge for the use of the applications and the content they deliver and access to the 'broadband' network will be 'bundled' in the price of the application or service. Eventually basic connectivity will disappear altogether as value is created by these new IP-based applications.

Service Footprint

In traditional carrier networks the services are linked to separate overlay networks and hence can only be delivered over the Telco's local network. Where services are created via IP-based applications, the distribution of the service is independent of local network and the market reach is worldwide.

Pricing Strategy for Ethernet Services

Carrier Ethernet services have in recent years been positioned as 'twice or four times the bandwidth at half the price'. For both competitive and incumbent carriers, this pricing model is unsustainable for the following reasons:

- High-speed connections require investment in both the access network and high-speed backbones and ROI would suffer significantly
- Cannibalisation of current E1 leased lines' revenues results in major disruption to the incumbent operators' business model
- Absence of value creation via the introduction of 'new' services and content drives the commoditisation of bandwidth even further
- Customer retention and loyalty is reduced since the focus is restricted to achieving the cheapest 'speeds and feeds'.

For the short term, the pricing policy for Carrier Ethernet services should take into consideration that pricing shapes the service demand and penetration rates. Furthermore, it should consider that having different price points for differentiated services increases revenues and profitability. In the longer term, the business strategy should focus on (value added services enabled by IP applications and convergence and not on basic connectivity alone.

Removing Barriers to Early Revenue

Due to the high granularity of Carrier Ethernet bandwidth, services can be offered in a 'pay as you grow' model making it easier for customers to accommodate increases as part of their yearly telecommunications budget. This approach reduces the ever-growing gap between demands for bandwidth, as it soars at exponential rates, and telecommunications budgets for enterprises which are currently growing at incremental rates. This creates the opportunity for carriers to up-sell their customer's further bandwidth upgrades in affordable steps. The net result is an early recognition of new service revenue for the carrier that would have otherwise been delayed due to large increments in bandwidth and costs using today's TDM-based services.

With Carrier Ethernet, no hardware change or upgrade is required and service providers can offer their customers the ability to change their own bandwidth profiles via web-based applications. New service revenues become only a customer 'click away', overcoming time-to-market barriers to revenue realisation and growth.

Differentiated Services Increase Revenue

Carrier Ethernet's scalability and flexibility enables carriers to offer their customers differential pricing for a wide variety of services options called Bandwidth profiles. Bandwidth profiles allow subscribers to purchase the bandwidth and performance levels they need allowing the service providers to price service incrementally. Service providers can offer multiple service instances per User Network Interface (UNI) to achieve higher profit margins with lower operational expenses. Being able to cater for all customers, from the low-end to the high-end of the market and anything in between, using the same Ethernet interface, significantly increases the service providers' average revenue per customer.

Selling Service, Not Bandwidth

With Carrier Ethernet, service providers will benefit from selling IP services that they otherwise wouldn't have been able to offer over a TDM infrastructure. Service creation and delivery are completely decoupled from one another. The creation of services depends entirely on innovative software within an IP and Ethernet development framework and not on a new network per service. This will result in more profitable and sustainable service revenue framework for the telecommunications industry.

Telcos may decide to specialise only in offering IP services that emulate existing Telco services. For example POTS by VoIP and E1/T1 leased lines by E1/T1 Circuit Emulation Service-over-Packet (CESoP). The Telco could also use Pseudo-wire to continue delivering ATM and Frame Relay to their existing customers but over their MPLS/IP network. However in an 'open' IP network other organisations could use the incumbent Telcos 'broadband' IP network to deliver services like VoIP, directly competing for the existing Telco POTS customer. The service that the customer will choose will depend on the 'value added' features and not on the basic commodity POTS service.

Table 3 on page 24 provides examples of IP applications which enable a number of service providers to deliver innovative services over other carrier's infrastructure.

Standards

> "The nice thing about standards is that there are so many of them to choose from"
> *Andrew S Tanenbaum*
> *(Computer Networks 1996)*

The application of Carrier Ethernet targeted at the access network is only one component in much larger wired and wireless carrier networks. There are therefore many organisations establishing standards for interoperability, signalling as well as Operations and Maintenance (OAM) that enable IP-based applications to operate end-to-end over this larger network. Some of the relevant bodies are listed in the table below.

Table 4: Relevant Standards Bodies

Standards Organisations	Website	Technology
Institute of Electrical and Electronics Engineers (IEEE)	www.ieee.org www.ieee802.org/3/efm	Ethernet, Ethernet-in-First-Mile
MetroEthernet Forum (MEF)	www.metroethernetforum.org	E-Line, E-LAN
FTTH Council Europe	www.europeftthcouncil.com	FTTH Council
The Internet Engineering Task Force (IETF)	www.ietf.org	Internet Protocols
MPLS and Frame Relay Alliance (MFA)	www.mfaforum.org	MPLS/ATM/FR
DSL FORUM	www.dslforum.org	xDSL
IETF PWE3 work group	www.ietf.org/html.charters/pwe3-charter.html	Pseudo-Wire
International Telecommunication Union (ITU)	www.itu.int	Telecommunication
3GPP (Third Generation Partnership Project)	www.3gpp.org	IP Multimedia System (IMS) & NextGen Networks
ETSI	www.etsi.org	Telecoms & Internet Converged Services & Protocols for Advanced Networks (TISPAN)
World Wide Web Consortium (W3C)	www.w3c.org	Web Services

Allied Telesis Carrier Ethernet Solutions

Allied Telesis International has been a developer and manufacturer of Ethernet products since 1987. Allied Telesis' extensive line-up of carrier-class Ethernet solutions is enabling the rapid adoption of IP/Ethernet as a core technology for the delivery of enhanced voice, video and data services to residential and business subscribers.

Allied Telesis offers an extensive range of carrier-grade IP/Ethernet products that support the most demanding broadband voice, video and data requirements. From multiservice Carrier Ethernet switches, carrier-grade integrated Multiservice Access Platforms (iMAP) and Coarse Wave Division Multiplexing (CWDM) optical transport, to intelligent Multiservice Gateways (iMG) and the simplest Ethernet adapter card or media converter, Allied Telesis' strength is in producing technically advanced products that enable Telco operators and service providers to increase revenues and maximise profits whilst reducing total Cost of Ownership of their network.

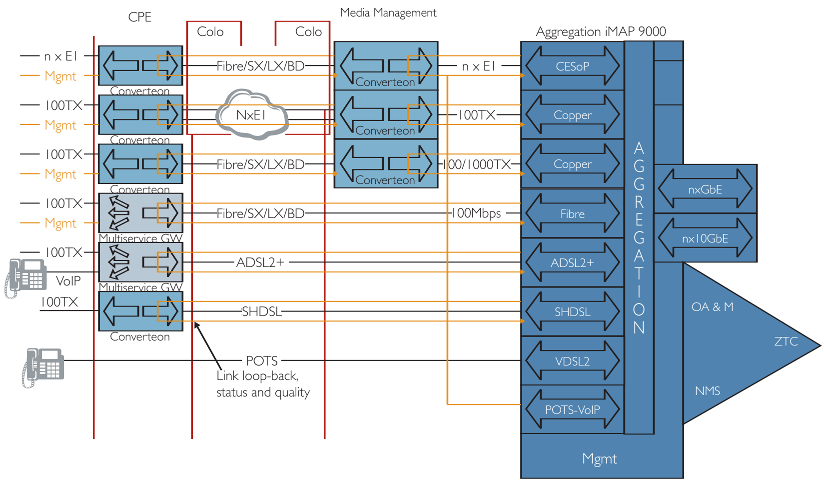


Figure 18: Allied Telesis Managed Carrier Ethernet Access

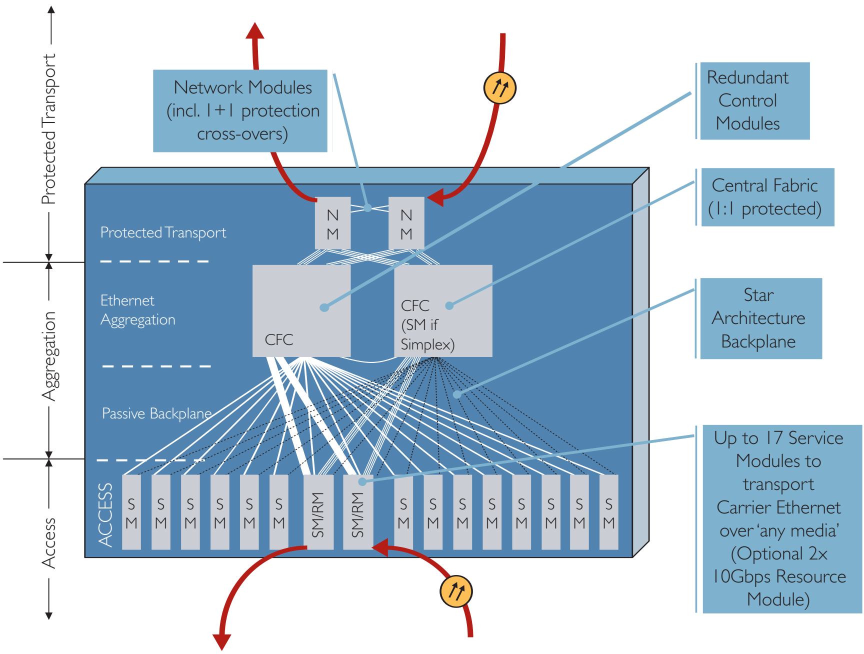


Figure 19: Allied Telesis Carrier Ethernet integrated Multiservice Access Platform (iMAP) Architecture

Allied Telesis

Allied Telesis is applying two decades of expertise in Ethernet-based technologies to deliver a comprehensive line of carrier-grade products and services that allow operators of all sizes to efficiently and economically deliver residential and business IP Triple Play services to their customers' premises. Allied Telesis International is leading the access network evolution towards IP and Carrier Ethernet with award-winning* platforms built for next-generation 21st century networks.

Allied Telesis' family of
integrated Multiservice Access Platforms and intelligent Multiservice Gateways

**In August 2005, Allied Telesis iMAP 9000 platforms were ranked top and best in class for both Out-Side Plant (Street Cabinet) and Central Office (CO) deployments.*

For further information about Allied Telesis Carrier Ethernet Solutions, please contact Rami Houbby on rami_houbby@alliedtelesis.com / +44 (0) 118 920 9800, visit the website at www.alliedtelesis.com/nsp or contact your local Allied Telesis sales office.

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